CERTIFICATE OF MAILING (37 CFR 1.8a)

I hereby certify this paper (along with any paper referred to as being attached or enclosed) is being deposited with the United States Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to: Mail Stop Appeal Brief – Patents; Commissioner for Patents; P.O. Box 1450; Alexandria, VA 22313-1450.

Joseph J Grimaldi
(Print name of person mailing paper)

08/19/03
(Date)

(Signature of person mailing paper)

G0518

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re patent application of:

Applicant:	Joong Jeon	Art Unit:	2823
Serial No.:	10/034,163	Examiner:	Suk San Foong
Filing Date:	December 27, 2001		

For: PREPARATION OF STACK HIGH-K GATE DIELECTRICS WITH NITRIDED LAYERS

APPEAL BRIEF

Mail Stop Appeal Brief – Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This brief is submitted in triplicate in connection with the appeal of the decision of the Examiner mailed June 16, 2003, finally rejecting claims 1 to 20 of the above-identified application. Authorization is hereby given to the Commissioner to charge Deposit Account No. 18-0988 the amount of $320.00 in connection with the filing of this Appeal Brief.

I. Real Party in Interest:

The real party in interest in the present appeal is the assignee, Advanced Micro Devices, Inc.

II. Related Appeals and Interferences:

Appellant, appellant's legal representatives, and/or the assignee of the present application are unaware of any appeals or interferences which will directly affect, which will be directly affected by, or which will have a bearing on the Board's decision in the pending appeal.

III. Status of Claims:

Claims 1-20 are pending and stand finally rejected. A copy of the claims is attached as Appendix A.

IV. Status of Amendments:

No amendments were filed after the final Office Action.

V. Background:

Fabrication of semiconductor devices, such as a metal-oxide-semiconductor (MOS) integrated circuit, involves numerous processing steps. In a semiconductor device, a gate dielectric, typically formed from silicon dioxide ("oxide"), is formed on a semiconductor substrate which is doped with either n-type or p-type impurities. For each MOS field effect transistor (MOSFET) being formed, a gate conductor is formed over the gate dielectric, and dopant impurities are introduced into the substrate to form a source and drain. A pervasive trend in modern integrated circuit manufacture is to produce transistors having feature sizes as small as possible. Many present processes employ features, such as gate conductors and interconnects, which have less than 0.18

μm critical dimension. As feature sizes continue to decrease, the size of the resulting transistor as well as the interconnect between transistors also decreases. Fabrication of smaller transistors allows more transistors to be placed on a single monolithic substrate, thereby allowing relatively large circuit systems to be incorporated on a single, relatively small die area.

As MOSFET feature sizes decrease, gate oxide thickness decreases as well. This decrease in gate oxide thickness is driven in part by the demands of overall device scaling. As gate conductor widths decrease, for example, other device dimensions must also decrease in order to maintain proper device operation. Early MOSFET scaling techniques involved decreasing all dimensions and voltages by a constant scaling factor, to maintain constant electric fields in the device as the feature size decreased. This approach has given way to more flexible scaling guidelines which account for operating characteristics of short-channel devices. For example, a maximum value of MOSFET sub-threshold current can be maintained while feature sizes shrink, by decreasing any or all of several quantities, including gate oxide thickness, operating voltage, depletion width, and junction depth, by appropriate amounts.

As a result of the continuing decrease in feature size, gate oxide thickness has been reduced so much that oxides are approaching thicknesses on the order of ten angstroms (Å). Unfortunately, thin oxide films may break down when subjected to an electric field, particularly for gate oxides less than 50 Å thick. It is probable that even for a relatively low gate voltage of 3V, electrons can pass through such a thin gate oxide by a quantum mechanical tunneling effect. In this manner, a tunneling current may undesirably form between the semiconductor substrate and the gate conductor, adversely affecting the operability of the device. It is postulated that some of these electrons may become entrapped within the gate oxide by, e.g., dangling bonds. As a result, a net negative charge density may form in the gate oxide. As the trapped charge

accumulates with time, the threshold voltage V_T may shift from its design specification. Breakdown of the gate oxide may also occur at even lower values of gate voltage, as a result of defects in the gate oxide. Such defects are unfortunately prevalent in relatively thin gate oxides. For example, a thin gate oxide often contains pinholes and/or localized voids due to unevenness at which the oxide grows on a less than perfect silicon lattice.

A more promising approach to further increasing gate dielectric capacitance may be to increase the permittivity of the gate dielectric. Permittivity, ε, of a material reflects the ability of the material to be polarized by an electric field. The permittivity of a material is typically described as its permittivity normalized to the permittivity of a vacuum, ε_0. Hence, the relative permittivity, referred to as the dielectric constant, of a material is defined as:

$$K=\varepsilon/\varepsilon_0$$

While silicon dioxide (sometimes simply referred to as "oxide") has a dielectric constant of approximately 3.9, other materials have higher K values. Silicon nitride ("nitride"), for example, has a K of about 6 to 9 (depending on formation conditions). Much higher K values of, for example, 20 or more can be obtained with various transition metal oxides including tantalum oxide (Ta_2O_5), barium strontium titanate ("BST"), and lead zirconate titanate ("PZT"). Using a high-K dielectric material for a gate dielectric would allow a high capacitance to be achieved even with a relatively thick dielectric layer. For example, a nitride gate dielectric with a K of 7.8 and a thickness of 100 Angstroms is substantially electrically equivalent to an oxide gate dielectric (K about 3.9) having a thickness of about 50 Angstroms. For even higher-K dielectric materials, even thicker gate dielectric layers could be formed while maintaining capacitance values higher than

are possible with even very thin oxide layers. In this way, the reliability problems associated with very thin dielectric layers may be avoided while transistor performance is increased.

One problem which has been reported relating to integration of high-K dielectric materials is oxidation of silicon by certain high-K dielectric materials when the high-K dielectric material is formed directly on a silicon substrate. Since oxidation results in formation of what may be referred to as a "standard-K" dielectric material, some of the benefit of the high-K dielectric material is considered to be lost. In addition, reactions considered adverse between the high-K dielectric material and standard-K dielectric materials may also occur.

Thus, a method of forming a relatively high-K dielectric material which either overcomes or takes advantage of such reactions, and which provides the electrical advantages of a higher K, is needed.

VI. Summary of Invention Defined in the Claims on Appeal:

In one embodiment, the invention as defined in the claims on Appeal relates to a method of making a semiconductor device **100** having a composite dielectric layer **110**, comprising: providing a semiconductor substrate **102**; depositing on the semiconductor substrate alternating sub-layers of a first dielectric material and a second dielectric material to form a layered dielectric structure **110** having at least two sub-layers (**110a** and **110c**) of the first dielectric material and at least one sub-layer **110b** of the second dielectric material, wherein the first dielectric material is a high-K dielectric material and the second dielectric material is a standard-K dielectric material, and at least one of the one or more dielectric material sub-layers contain nitrogen implanted therein using a nitridation step; and annealing the layered dielectric structure at an elevated

temperature to form a composite dielectric layer **110rp** about the boundary of each first dielectric material layer/second dielectric material layer. (See Specification, page 3, line 25 to page 4, line 5 and Figure 1.)

In another embodiment, the invention as defined in the claims on Appeal relates to a method of making a semiconductor device having a composite dielectric layer. In this embodiment, the method includes the steps of: providing a semiconductor substrate **102**; depositing on the semiconductor substrate alternating sub-layers of a first dielectric material and a second dielectric material to form a layered dielectric structure **110** having at least two sub-layers of the first dielectric material (**110a** and **110c**) and at two sub-layers (**110b** and **110d**) of the second dielectric material, wherein the first dielectric material is a standard-K dielectric material and the second dielectric material is a high-K dielectric material, and at least one of dielectric material sub-layers contain nitrogen implanted therein using a nitridation step; and annealing the layered dielectric structure at an elevated temperature to form a composite dielectric layer **110rp** about the boundary of each first dielectric material layer/second dielectric material layer. (See Specification, page 4, lines 6 to 16 and Figures 1 and 6.)

In another embodiment, the invention as defined in the claims on Appeal relates to a method of making a semiconductor device having a composite dielectric layer. In this embodiment, the method includes the steps of: providing a semiconductor substrate **102**; subjecting the semiconductor substrate to a nitridation step to produce a layer of standard-K dielectric material in the upper portion of one side of the semiconductor substrate; depositing on the standard-K dielectric side of the semiconductor substrate alternating sub-layers of a first dielectric material and a second dielectric material to form a layered dielectric structure **110** having at least one sub-layer (**110a** and **110c**) of the first dielectric material and at least one sub-layer of the second dielectric material (**110b**), wherein the first dielectric material is a high-K dielectric material and the second dielectric material is a standard-K dielectric material,

and at least one of the one or more dielectric material sub-layers contain nitrogen implanted therein using a nitridation step; and annealing the layered dielectric structure at an elevated temperature to form a composite dielectric layer **110rp** about the boundary of each first dielectric material layer/second dielectric material layer. (See Specification, page 4, lines 17 to 30 and Figure 1.)

VII. Applied Art:

Currently there is no applied art remaining against the claims on appeal.

VIII. Issues:

1. Whether claims 1-20 satisfy 35 U.S.C. § 112, first paragraph, as being enabled by the specification, claims and Figures, as filed.

IX. Grouping of Claims:

A. Claims 1, 3 to 5 and 7 to 9 stand or fall together.

B. Claims 2 and 6 stand or fall together.

C. Claims 10, 12 to 14 and 16 to 19 stand or fall together.

D. Claims 11 and 15 stand or fall together.

E. Claim 20 stands or falls alone.

X. Argument:

The Board should reverse the final rejections of the Examiner for the following reasons.

i. The claims as presently worded are adequately supported and enabled by the specification, claims and Figures as originally filed.

Group A: The final rejection of claims 1, 3 to 5 and 7 to 9 under 35 U.S.C. § 112, first paragraph as containing subject matter which was not adequately described and/or enabled in the specification as filed is improper and should be reversed because the subject matter of these claims is supported by the specification and drawings as filed. More specifically, the Examiner contends that the specification as originally filed does not adequately describe and/or enable "one of ordinary skill in the art to determine suitable combinations of 'high-K dielectric material' and 'standard-K dielectric material' that will form a composite dielectric layer" as claimed. The Examiner continues on to state that the specification fails to define the chemical reactivity of the dielectric materials recited therein, and as such, one of ordinary skill in that art would not be able to determine what high-K dielectric material could be paired with a given standard-K dielectric material, or vice versa.

Various standard-K and high-K dielectric materials are known to those of ordinary skill in the art. Representative examples of standard-K and high-K dielectric materials are disclosed in the specification as filed (see, e.g., pages 6 and 7 of the specification as filed). The reactivity of these and other dielectric materials vis-a-vis one another are known to those of ordinary skill in the art.

Given the disclosure contained in the specification as filed, and the knowledge attributable to one of ordinary skill in the art, such a skilled artisan would recognize upon reading and understanding the specification the possible combinations of high-K and standard-K material given the nature of the dielectric materials disclosed within the specification as filed.

That is, the dielectric materials contemplated by the present invention are well known to those of ordinary skill in the art. As such, a skilled artisan would be able to determine combinations of high-K and standard-K dielectric materials which would yield the claimed results.

As explained by the Federal Circuit:

> Requiring inclusion in the patent of known scientific/technological information would add an imprecise and open-ended criterion to the content of patent specifications, could greatly enlarge the content of patent specifications and unnecessarily increase the cost of preparing and prosecuting patent applications, and could tend to obfuscate rather than highlight the contribution to which the patent is directed. A patent is not a scientific treatise, but a document that presumes a readership skilled in the field of the invention.

Ajinomoto Co., Inc. v. Archer-Daniels-Midland Co., 56 USPQ 2d 1332, 1338 (Fed. Cir. 2000), cert. denied, 532 U.S. 1019 (2001) (citing W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 USPQ 303, 315 (Fed. Cir. 1983) ("Patents, however, are written to enable those skilled in the art to practice the invention not the public"), cert. denied, 469 U.S. 851 (1984)).

Accordingly, given the disclosure contained in the specification as filed and the knowledge attributable to one of ordinary skill in the art, claims 1, 3 to 5 and 7 to 9 are adequately supported and/or enabled by the specification as filed. As such, reversal of the rejection of claims 1, 3 to 5 and 7 to 9 under 35 U.S.C. § 112, first paragraph, is requested.

Group B: The final rejection of claims 2 and 6, which depend directly from claim 1, under 35 U.S.C. § 112, first paragraph as containing subject matter which was not adequately described and/or enabled in the specification as filed is improper and should be reversed because the subject matter of these claims is supported by the specification and drawings as filed. More specifically, the Examiner contends that the specification as originally filed does not adequately describe and/or enable "one of ordinary skill in the art to determine suitable combinations of 'high-K dielectric material' and 'standard-K dielectric material' that will form a composite dielectric layer" as

claimed. The Examiner continues on to state that the specification fails to define the chemical reactivity of the dielectric materials recited therein, and as such, one of ordinary skill in that art would not be able to determine what high-K dielectric material could be paired with a given standard-K dielectric material, or vice versa.

Various standard-K and high-K dielectric materials are known to those of ordinary skill in the art. Representative examples of standard-K and high-K dielectric materials are disclosed in the specification as filed (see, e.g., pages 6 and 7 of the specification as filed). The reactivity of these and other dielectric materials vis-a-vis one another are known to those of ordinary skill in the art.

Given the disclosure contained in the specification as filed, and the knowledge attributable to one of ordinary skill in the art, such a skilled artisan would recognize upon reading and understanding the specification the possible combinations of high-K and standard-K material given the nature of the dielectric materials disclosed within the specification as filed.

That is, the dielectric materials contemplated by the present invention are well known to those of ordinary skill in the art. As such, a skilled artisan would be able to determine combinations of high-K and standard-K dielectric materials which would yield the claimed results.

As explained by the Federal Circuit:

> Requiring inclusion in the patent of known scientific/technological information would add an imprecise and open-ended criterion to the content of patent specifications, could greatly enlarge the content of patent specifications and unnecessarily increase the cost of preparing and prosecuting patent applications, and could tend to obfuscate rather than highlight the contribution to which the patent is directed. A patent is not a scientific treatise, but a document that presumes a readership skilled in the field of the invention.

Ajinomoto Co., Inc. v. Archer-Daniels-Midland Co., 56 USPQ 2d 1332, 1338 (Fed. Cir. 2000), cert. denied, 532 U.S. 1019 (2001) (citing W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 USPQ 303, 315 (Fed. Cir. 1983) ("Patents, however, are written to enable those skilled in the art to practice the invention not the public"), cert. denied, 469 U.S. 851 (1984)).

Accordingly, given the disclosure contained in the specification as filed and the knowledge attributable to one of ordinary skill in the art, claims 2 and 6 are adequately supported and/or enabled by the specification as filed. As such, reversal of the rejection of claims 2 and 6 under 35 U.S.C. § 112, first paragraph, is requested.

Group C: The final rejection of claims 10, 12 to 14 and 16 to 19 under 35 U.S.C. § 112, first paragraph as containing subject matter which was not adequately described and/or enabled in the specification as filed is improper and should be reversed because the subject matter of these claims is supported by the specification and drawings as filed. More specifically, the Examiner contends that the specification as originally filed does not adequately describe and/or enable "one of ordinary skill in the art to determine suitable combinations of 'high-K dielectric material' and 'standard-K dielectric material' that will form a composite dielectric layer" as claimed. The Examiner continues on to state that the specification fails to define the chemical reactivity of the dielectric materials recited therein, and as such, one of ordinary skill in that art would not be able to determine what high-K dielectric material could be paired with a given standard-K dielectric material, or vice versa.

Various standard-K and high-K dielectric materials are known to those of ordinary skill in the art. Representative examples of standard-K and high-K dielectric materials are disclosed in the specification as filed (see, e.g., pages 6 and 7 of the specification as filed). The reactivity of these and other dielectric materials vis-a-vis one another are known to those of ordinary skill in the art.

Given the disclosure contained in the specification as filed, and the knowledge attributable to one of ordinary skill in the art, such a skilled artisan would recognize upon reading and understanding the specification the possible combinations of high-K and standard-K material given the nature of the dielectric materials disclosed within the specification as filed.

That is, the dielectric materials contemplated by the present invention are well known to those of ordinary skill in the art. As such, a skilled artisan would be able to determine combinations of high-K and standard-K dielectric materials which would yield the claimed results.

As explained by the Federal Circuit:

> Requiring inclusion in the patent of known scientific/technological information would add an imprecise and open-ended criterion to the content of patent specifications, could greatly enlarge the content of patent specifications and unnecessarily increase the cost of preparing and prosecuting patent applications, and could tend to obfuscate rather than highlight the contribution to which the patent is directed. A patent is not a scientific treatise, but a document that presumes a readership skilled in the field of the invention.

Ajinomoto Co., Inc. v. Archer-Daniels-Midland Co., 56 USPQ 2d 1332, 1338 (Fed. Cir. 2000), cert. denied, 532 U.S. 1019 (2001) (citing W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 USPQ 303, 315 (Fed. Cir. 1983) ("Patents, however, are written to enable those skilled in the art to practice the invention not the public"), cert. denied, 469 U.S. 851 (1984)).

Accordingly, given the disclosure contained in the specification as filed and the knowledge attributable to one of ordinary skill in the art, claims 10, 12 to 14 and 16 to 19 are adequately supported and/or enabled by the specification as filed. As such, reversal of the rejection of claims 10, 12 to 14 and 16 to 19 under 35 U.S.C. § 112, first paragraph, is requested.

Group D: The final rejection of claims 11 and 15, which depend directly from claim 10, under 35 U.S.C. § 112, first paragraph as containing subject matter which was not adequately described and/or enabled in the specification as filed is improper and should be reversed because the subject matter of these claims is supported by the specification and drawings as filed. More specifically, the Examiner contends that the specification as originally filed does not adequately describe and/or enable "one of ordinary skill in the art to determine suitable combinations of 'high-K dielectric material' and 'standard-K dielectric material' that will form a composite dielectric layer" as claimed. The Examiner continues on to state that the specification fails to define the chemical reactivity of the dielectric materials recited therein, and as such, one of ordinary skill in that art would not be able to determine what high-K dielectric material could be paired with a given standard-K dielectric material, or vice versa.

Various standard-K and high-K dielectric materials are known to those of ordinary skill in the art. Representative examples of standard-K and high-K dielectric materials are disclosed in the specification as filed (see, e.g., pages 6 and 7 of the specification as filed). The reactivity of these and other dielectric materials vis-a-vis one another are known to those of ordinary skill in the art.

Given the disclosure contained in the specification as filed, and the knowledge attributable to one of ordinary skill in the art, such a skilled artisan would recognize upon reading and understanding the specification the possible combinations of high-K and standard-K material given the nature of the dielectric materials disclosed within the specification as filed.

That is, the dielectric materials contemplated by the present invention are well known to those of ordinary skill in the art. As such, a skilled artisan would be able to determine combinations of high-K and standard-K dielectric materials which would yield the claimed results.

As explained by the Federal Circuit:

> Requiring inclusion in the patent of known scientific/technological information would add an imprecise and open-ended criterion to the content of patent specifications, could greatly enlarge the content of patent specifications and unnecessarily increase the cost of preparing and prosecuting patent applications, and could tend to obfuscate rather than highlight the contribution to which the patent is directed. A patent is not a scientific treatise, but a document that presumes a readership skilled in the field of the invention.

Ajinomoto Co., Inc. v. Archer-Daniels-Midland Co., 56 USPQ 2d 1332, 1338 (Fed. Cir. 2000), cert. denied, 532 U.S. 1019 (2001) (citing W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 USPQ 303, 315 (Fed. Cir. 1983) ("Patents, however, are written to enable those skilled in the art to practice the invention not the public"), cert. denied, 469 U.S. 851 (1984)).

Accordingly, given the disclosure contained in the specification as filed and the knowledge attributable to one of ordinary skill in the art, claims 11 and 15 are adequately supported and/or enabled by the specification as filed. As such, reversal of the rejection of claims 11 and 15 under 35 U.S.C. § 112, first paragraph, is requested.

Group E: The final rejection of claim 20 under 35 U.S.C. § 112, first paragraph as containing subject matter which was not adequately described and/or enabled in the specification as filed is improper and should be reversed because the subject matter of these claims is supported by the specification and drawings as filed. More specifically, the Examiner contends that the specification as originally filed does not adequately describe and/or enable "one of ordinary skill in the art to determine suitable combinations of 'high-K dielectric material' and 'standard-K dielectric material' that will form a composite dielectric layer" as claimed. The Examiner continues on to state that the specification fails to define the chemical reactivity of the dielectric materials recited

therein, and as such, one of ordinary skill in that art would not be able to determine what high-K dielectric material could be paired with a given standard-K dielectric material, or vice versa.

Various standard-K and high-K dielectric materials are known to those of ordinary skill in the art. Representative examples of standard-K and high-K dielectric materials are disclosed in the specification as filed (see, e.g., pages 6 and 7 of the specification as filed). The reactivity of these and other dielectric materials vis-a-vis one another are known to those of ordinary skill in the art.

Given the disclosure contained in the specification as filed, and the knowledge attributable to one of ordinary skill in the art, such a skilled artisan would recognize upon reading and understanding the specification the possible combinations of high-K and standard-K material given the nature of the dielectric materials disclosed within the specification as filed.

That is, the dielectric materials contemplated by the present invention are well known to those of ordinary skill in the art. As such, a skilled artisan would be able to determine combinations of high-K and standard-K dielectric materials which would yield the claimed results.

As explained by the Federal Circuit:

> Requiring inclusion in the patent of known scientific/technological information would add an imprecise and open-ended criterion to the content of patent specifications, could greatly enlarge the content of patent specifications and unnecessarily increase the cost of preparing and prosecuting patent applications, and could tend to obfuscate rather than highlight the contribution to which the patent is directed. A patent is not a scientific treatise, but a document that presumes a readership skilled in the field of the invention.

Ajinomoto Co., Inc. v. Archer-Daniels-Midland Co., 56 USPQ 2d 1332, 1338 (Fed. Cir. 2000), cert. denied, 532 U.S. 1019 (2001) (citing W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 USPQ 303, 315 (Fed. Cir. 1983) ("Patents, however, are written to enable those skilled in the art to practice the invention not the public"), cert. denied, 469 U.S. 851 (1984)).

Accordingly, given the disclosure contained in the specification as filed and the knowledge attributable to one of ordinary skill in the art, claim 20 is adequately supported and/or enabled by the specification as filed. As such, reversal of the rejection of claim 20 under 35 U.S.C. § 112, first paragraph, is requested.

XI Conclusion:

In view of the foregoing, it is respectfully submitted that the claims are supprted and/or enabled by the specification as filed and that the final rejection should be reversed.

The Commissioner is hereby authorized to charge Deposit Account No. 18-0988 the amount of $320.00 in connection with the submission of this Appeal Brief.

Should any additional fee be due in connection with the filing of this Appeal Brief, the Commissioner is hereby authorized to charge Deposit Account No. 18-0988, Attorney Docket No. **G0518**.

Respectfully submitted,
RENNER, OTTO, BOISSELLE & SKLAR, L.L.P.

By: ____________________
Joseph J. Crimaldi
Reg. No. 41,690

1621 Euclid Avenue
Nineteenth Floor
Cleveland, Ohio 44115
Tel: (216) 621-1113
Fax: (216) 621-6165

Appendix A

1. A method of making a semiconductor device having a composite dielectric layer, comprising:

providing a semiconductor substrate;

depositing on the semiconductor substrate alternating sub-layers of a first dielectric material and a second dielectric material to form a layered dielectric structure having at least two sub-layers of the first dielectric material and at least one sub-layer of the second dielectric material,

wherein the first dielectric material is a high-K dielectric material and the second dielectric material is a standard-K dielectric material, and at least one of the one or more dielectric material sub-layers contain nitrogen implanted therein using a nitridation step; and

annealing the layered dielectric structure at an elevated temperature to form a composite dielectric layer about the boundary of each first dielectric material layer/second dielectric material layer.

2. The method of claim 1, wherein the standard-K dielectric material comprises at least one of silicon dioxide, silicon oxynitride, silicon nitride, and silicon-rich silicon nitride.

3. The method of claim 2, wherein during the step of annealing, the first dielectric material and the second dielectric material form a silicon-containing reaction product in at least one of the composite dielectric layers.

4. The method of claim 2, wherein at least one of the composite dielectric layers comprise a silicate.

5. The method of claim 3, wherein the reaction product comprises a metal atom, a silicon atom and at least one of an oxygen atom or a nitrogen atom.

6. The method of claim 1, wherein the high-K dielectric material comprises at least one of hafnium oxide, zirconium oxide, tantalum oxide, titanium dioxide, cesium oxide, lanthanum oxide, tungsten oxide, yttrium oxide, bismuth silicon oxide ($Bi_4Si_2O_{12}$), barium strontium oxide ($Ba_{1-x}Sr_xO_3$), BST ($Ba_{1-x}Sr_xTiO_3$), PZN ($PbZn_xNb_{1-x}O_3$), PZT ($PbZr_xTi_{1-x}O_3$) and PST ($PbSc_xTa_{1-x}O_3$).

7. The method of claim 1, wherein each one composite dielectric layer comprises at least a portion of the sub-layers of the first dielectric material and the second dielectric material, separated by a sub-layer of a reaction product of the first dielectric material and the second dielectric material.

8. The method of claim 1, wherein each composite dielectric layer comprises a substantially uniform layer of a reaction product of the first dielectric material and the second dielectric material.

9. The method of claim 1, wherein thicknesses of the sub-layers is selected to control ratios of metal to silicon to oxygen in at least one of the composite dielectric layers.

10. A method of making a semiconductor device having a composite dielectric layer, comprising:

providing a semiconductor substrate;

depositing on the semiconductor substrate alternating sub-layers of a first dielectric material and a second dielectric material to form a layered dielectric structure having at least two sub-layers of the first dielectric material and at two sub-layers of the second dielectric material,

wherein the first dielectric material is a standard-K dielectric material and the second dielectric material is a high-K dielectric material, and at least one of dielectric material sub-layers contain nitrogen implanted therein using a nitridation step; and

annealing the layered dielectric structure at an elevated temperature to form a composite dielectric layer about the boundary of each first dielectric material layer/second dielectric material layer.

11. The method of claim 10, wherein the standard-K dielectric material comprises at least one of silicon dioxide, silicon oxynitride, silicon nitride, and silicon-rich silicon nitride.

12. The method of claim 11, wherein during the step of annealing, the first dielectric material and the second dielectric material form a silicon-containing reaction product in at least one of the composite dielectric layers.

13. The method of claim 11, wherein at least one of the composite dielectric layers comprise a silicate.

14. The method of claim 12, wherein the reaction product comprises a metal atom, a silicon atom and at least one of an oxygen atom or a nitrogen atom.

15. The method of claim 10, wherein the high-K dielectric material comprises at least one of hafnium oxide, zirconium oxide, tantalum oxide, titanium dioxide, cesium oxide, lanthanum oxide, tungsten oxide, yttrium oxide, bismuth silicon oxide ($Bi_4Si_2O_{12}$), barium strontium oxide ($Ba_{1-x}Sr_xO_3$), BST ($Ba_{1-x}Sr_xTiO_3$), PZN ($PbZn_xNb_{1-x}O_3$), PZT ($PbZr_xTi_{1-x}O_3$) and PST ($PbSc_xTa_{1-x}O_3$).

16. The method of claim 10, wherein each one composite dielectric layer comprises at least a portion of the sub-layers of the first dielectric material and the second dielectric material, separated by a sub-layer of a reaction product of the first dielectric material and the second dielectric material.

17. The method of claim 10, wherein each composite dielectric layer comprises a substantially uniform layer of a reaction product of the first dielectric material and the second dielectric material.

18. The method of claim 10, wherein thicknesses of the sub-layers is selected to control ratios of metal to silicon to oxygen in at least one of the composite dielectric layers.

19. The method of claim 10, wherein the at least two dielectric material sub-layers contain nitrogen implanted therein using a nitridation step.

20. A method of making a semiconductor device having a composite dielectric layer, comprising:

providing a semiconductor substrate;

subjecting the semiconductor substrate to a nitridation step to produce a layer of standard-K dielectric material in the upper portion of one side of the semiconductor substrate;

depositing on the standard-K dielectric side of the semiconductor substrate alternating sub-layers of a first dielectric material and a second dielectric material to form a layered dielectric structure having at least one sub-layer of the first dielectric material and at least one sub-layer of the second dielectric material,

wherein the first dielectric material is a high-K dielectric material and the second dielectric material is a standard-K dielectric material, and at least one of the one or more dielectric material sub-layers contain nitrogen implanted therein using a nitridation step; and

annealing the layered dielectric structure at an elevated temperature to form a composite dielectric layer about the boundary of each first dielectric material layer/second dielectric material layer.